Seabed Variability and its Influence on Acoustic Prediction Uncertainty

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LONG TERM GOALS

A basic tenet of the Office of Naval Research's "Uncertainty in the Natural Environment" Defense Research Initiative (Uncertainty DRI) is that, in any strategic situation, environmental parameters will never be known in complete enough detail to enable a perfectly accurate acoustic detection. Our group has been funded address acoustic uncertainty associated with bottom and subbottom variability. In particular, we will (1) assess and characterize the seafloor variability, and (2) determine the impact of seafloor variability on acoustic prediction uncertainty.

OBJECTIVES

This grant is one component of a team effort (see below). John Goff will be primarily responsible for investigating the statistical properties of seafloor and subseafloor variability and for translating resultant characterizations into seafloor models that can be used in the acoustic modeling efforts and compared against geophysical modeling efforts. Goff has extensive experience conducting statistical characterization of seafloor morphology on the shelf, slope, and deep ocean, as well as other geophysical fields (sea ice, crustal heterogeneity). Under the auspices of the ONR STRATAFORM program, he has been involved with collection and analysis of swath mapping and physical property data, particularly with regards to ground truthing sidescan backscatter data (Figure 1). Such field work and analysis will continue as part of the ONR Geoclutter and Mine Burial programs. These data are (or will be) well suited to statistical analysis, because particular attention will be paid to collecting samples at a wide range of sampling scales. In addition, Goff has a strong background in generating morphological realizations from statistical descriptions (simulations), either unconditioned or conditioned on preexisting data. Goff will therefore be well positioned to satisfy the input requirements of acoustic modelers working in this effort.

APPROACH

The bottom characterization group within the Uncertainty DRI includes the following participants:

John Goff - Statistical characterization of surface/sub-surface properties/morphology
Charles Holland - Acoustic measurements/geoacoustic inversion
Kevin LePage - Reverberation modeling
Robert Odom - Acoustic propagation modeling (forward/inverse)
Lincoln Pratson – Predictive geoacoustic modeling; lab-generated 3D strata
James Syvitski – Predictive geophysical modeling

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14. ABSTRACT
A basic tenet of the Office of Naval Research's Uncertainty in the Natural Environment Defense Research Initiative (Uncertainty DRI) is that, in any strategic situation, environmental parameters will never be known in complete enough detail to enable a perfectly accurate acoustic detection. Our group has been funded address acoustic uncertainty associated with bottom and subbottom variability. In particular, we will (1) assess and characterize the seafloor variability, and (2) determine the impact of seafloor variability on acoustic prediction uncertainty.

15. SUBJECT TERMS

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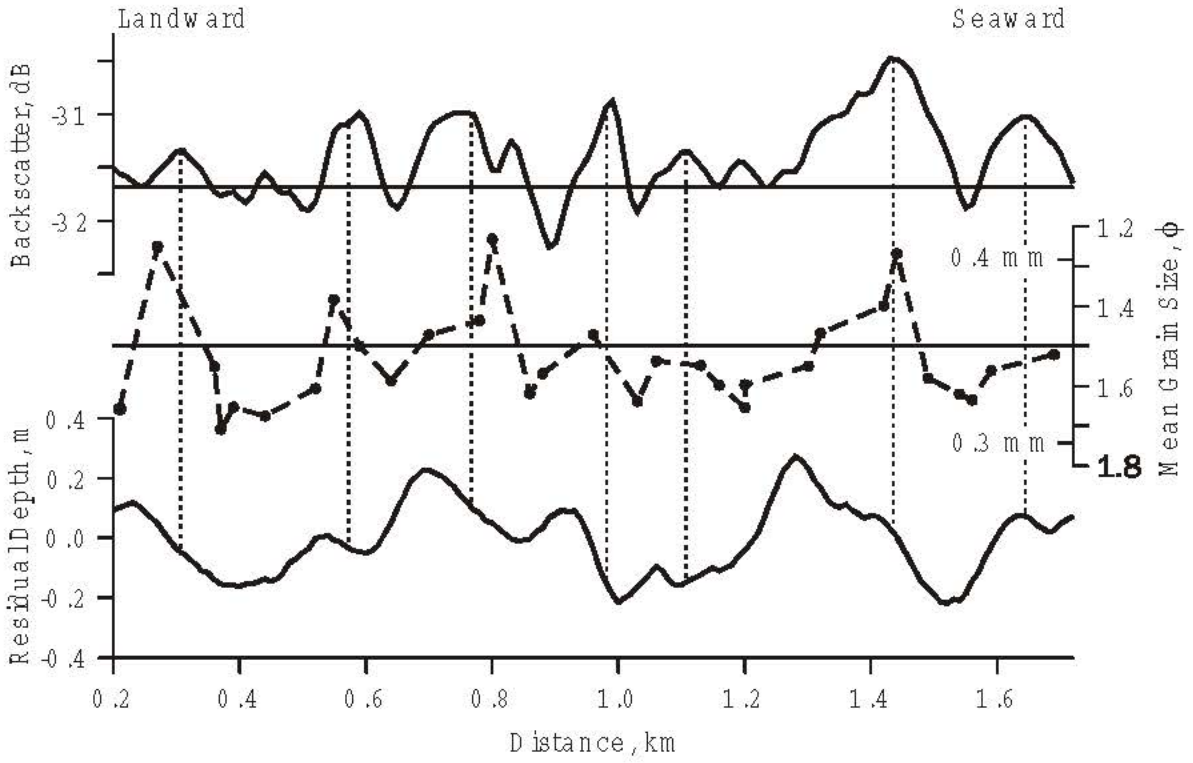

Figure 1. Coincident backscatter, mean grain size, and residual bathymetric depth over a series of low submarine dunes on the New Jersey shelf, illustrating variability and morphology and sedimentary process on scales important to the acoustic problem. Backscatter and bathymetry data were collected by the STRATAFORM program using a 95 kHz swath multibeam system (Goff et al., 1999). Vertical dashed lines indicate the correspondence of high backscatter and larger mean grain sizes with the seaward facing dune slopes. From Goff et al. (2000).

Goff's specific tasks will be to:

(1) Act as liaison for Geoclutter field efforts on the New Jersey shelf, ensuring that products are generated from that program that will be useful to the Uncertainty work.

(2) With available data, establish a statistical characterization of surface morphology and of surface and subsurface sediment properties. There are or will be, as part of STRATAFORM and Geoclutter, several abundant sources of data for this effort on the New Jersey shelf: (1) multibeam bathymetric data; (2) direct measurements of surface and near-surface properties from samples and in-situ measurements (perhaps up to 500 stations); (3) indirect (but ground-truthed) measurements of surface properties via sidescan data; (4) limited direct measurements of physical properties at depth base on the STRATAFORM long-coring effort; and (5) indirect measurement of properties at depth based on analysis of chirp seismic reflection data. Suitable data suites from other areas of interest may also be used for statistical characterization, including the Eel River margin, which is also a STRATAFORM natural lab site, and the Mediterranean regions for which Charles Holland has considerable data.

(3) Work with geophysical modelers on the team (Syvitski, Pratson) to evaluate statistical variability reflected in the modeling products, and compare to statistical characterizations based on data.

(4) Work with acoustic modelers on the team (Holland, Odom, LePage) to generate synthetic seafloor and subseafloor models, based on statistical characterizations, that can be used in numerical acoustic experiments for the evaluation of uncertainty.

WORK COMPLETED

This proposal was funded late in FY2001 to enable travel to the first Uncertainty DRI workshop in June of 2001. During the summer of 2001, Goff participated in three Geoclutter field efforts, data from which will also be used in the Uncertainty DRI work. Otherwise, work has not yet commenced on this project. The expected work to be completed includes:

(1) Generate appropriate statistical characterizations of surface morphology and surficial sedimentary properties for available data sets (yrs 1 – 3).

(2) Generate seafloor models appropriate to statistical characterizations (unconditional and unconditional simulations) for use in acoustic modeling efforts (yrs 2-3).

(3) Examine statistical variability produced by geophysical modeling efforts and compare to data characterizations (yrs 3-4)

RESULTS

Results have not yet been generated for this project

IMPACT/APPLICATIONS

In order to address the principal issues mentioned above, we anticipate an approach that blends the key disciplines of geology/geophysics (G&G) and acoustics, linked by the field of geoacoustics. The field of geoacoustics was born out of the recognition that in order to predict the effect of the seafloor on acoustic systems, a physics-based approach was required, in which the physical properties of the seabed were identified and measured. The science of geoacoustics is to identify the key properties that control acoustic interaction and parameterize them as concisely as possible. Thus, a geoacoustic model is not an exact description of the seafloor, but it does include the important physics of the problem being addressed. The current generation of seafloor databases over-simplifies the important physics, and thus geoacoustics, in some shallow water environments.

For many years, the underwater acoustics community has probed the sediment geoacoustics through inverse modeling of acoustic measurements (e.g., propagation, reverberation) or via empirical relations or models. From the other end, the G&G community has developed its strategies to obtain sediment geoacoustics such as advanced coring, in-situ sampling devices, and modeling (e.g., sediment deposition, transport).

We expect our work to bring together these two disciplines, G&G and acoustics, at the intersection of geoacoustics in order to bring to bear the very best tools of both disciplines and the concomitant synergy upon the problem of Uncertainty in the acoustic problem. In fact, we believe that a

combination of G&G and acoustics is not the only the best but the only way to significantly advance the understanding of seafloor variability and its effect on acoustic predictions.

TRANSITIONS

Our effort deliberately stops far short of an end-to-end approach to the acoustic uncertainty problem in order to focus on this crucial aspect: acoustic interaction with the seabed. We see our team transitioning and providing seafloor variability products to other Uncertainty DRI teams addressing oceanographic variability, signal processing, and sensing/information dominance issues. In particular we see our products feeding directly into efforts lead by the Miyamoto, Abbott/Robinson, and Schmidt teams. Our products would also fit into any other team that requires knowledge of seafloor variability and its effect on the uncertainty of propagation/reverberation prediction.

RELATED PROJECTS

This project will make heavy use of data collected during the ONR STRATAFORM and Geoclutter programs on the New Jersey shelf.

REFERENCES

Goff, J. A., D. J. P. Swift, C. S. Duncan, L. A. Mayer, and J. Hughes-Clarke, High resolution swath sonar investigation of sand ridge, dune and ribbon morphology in the offshore environment of the New Jersey Margin, *Mar. Geol*., *161*, 309-339, 1999.

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